Presentation description of LAPC paper / poster entitled

Phased Array Antenna Suitable for a Relay-aided WiMAX network

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This presentation describes a phased array antenna which is suitable for a Relay-aided WiMAX Network and able to perform beamforming scenarios to establish the communication between the Relay Station (RS) and the Base Station (BS).

Following the introductory part, title and abstract, **slide 3** depicts the concept of relaying in 4G networks. In **slide 4** the technical characteristics of the antenna array are presented in terms of the utilized substrates and the form of radiation elements. The structure of the proposed phased array comprises a high and a low permittivity substrates, together with a modified E-shaped radiation element to obtain the required gain and bandwidth values.

In **slide 5** the experimental S_{11} parameter of a single modified E-shaped radiation element is presented, providing operation at the 3.5GHz frequency band and satisfactory results in terms of experimental Gain and Half Power Beam-width. The antenna array which is also referred to as backhaul antenna is proved to be compliant with the air-interface specifications of the IEEE802.16j standard which implies a Relay-based mobile WiMAX network.

In **slides 6 and 7** two beam-forming scenarios are defined and simulated for the proposed antenna array, requiring main lobe of radiation at specific angle and suppressed side lobes. Results are efficient and are obtained by properly adjusting the amplitude and phase of the excitation currents.

A beam-forming module for realizing the required radiation pattern is designed and simulated in **slides 8 and 9**. The proposed design is a planar microstrip circuit that uses Wilkinson power divider technology for power splitting and incorporated SMT attenuator and phase shifter chips for realizing beam-forming operation.

In **slide 10**, the presented beam-forming module is tested by setting three attenuation/phase scenarios and obtaining the S_{11} parameter, proving 650MHz bandwidth in the 3.5GHz frequency band. Moreover simulated Insertion loss (S_{21}) and Isolation (S_{32}) for scenario 1 for the 3.5 GHz frequency band is presented in **slide 11**. Conclusions regarding the proposed phased array are presented in **slide 12**, showing the application efficiency and validity of the design and **slide 13** depicts a drawing with the total phased array configuration.

Phased Array Antenna Suitable for a Relay-aided WiMAX Network

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Abstract

- A planar 4×4 phased array including modified E-shaped radiation elements is designed and fabricated to be incorporated in a Relay Station (RS) for realizing the communication with the Base Station (BS).

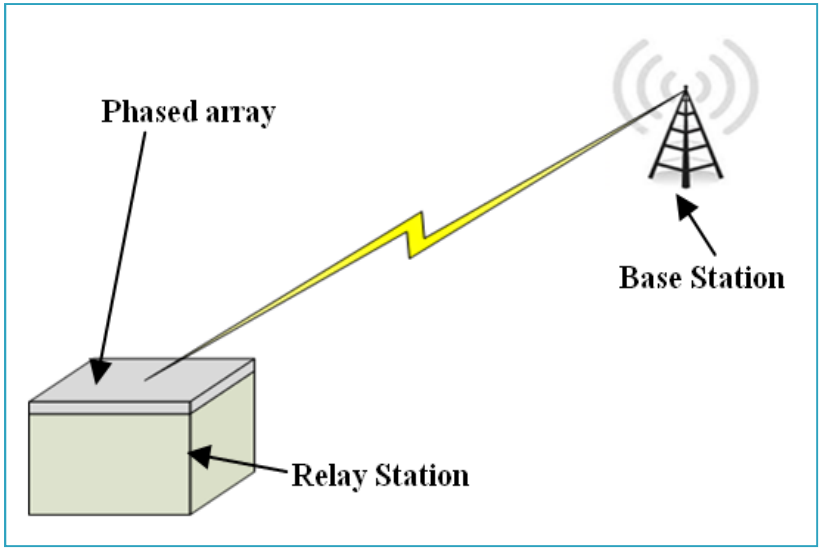
- The proposed array provides 12.4% bandwidth at the 3.5GHz frequency band and gain of 21.2dB.

- Moreover a beam-forming module is designed and simulated, aimed to be connected to the proposed array, realizing beam-forming applications.

- This module provides 650 MHz bandwidth around 3.5GHz frequency band and is used for proper power division and controlling the amplitude/phase of the excitation currents that will feed the planar 4×4 array.

Relay Stations

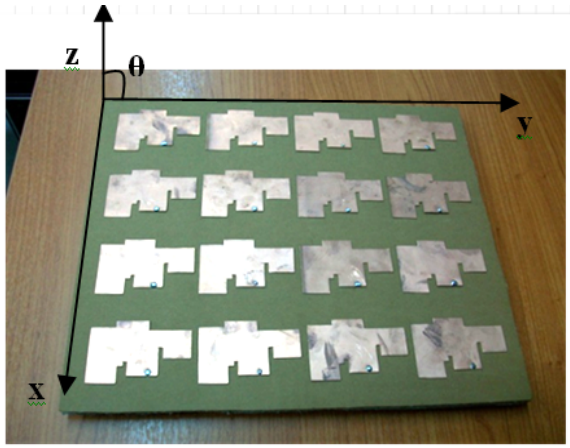
- Relay Stations are network devices set in appropriate places to receive, enhance and retransmit radio signal increasing throughput and extend network's coverage.
- These devices should be equipped with a low profile, easy to mount flexible antenna array for realizing the communication between the Relay Station and the Base station.



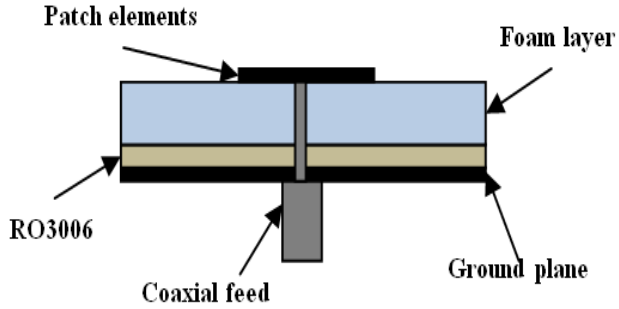
- RS-BS communication

Phased array design and evaluation

- A modified E-shaped patch array is designed based on a composite substrate, comprising:
- a high permittivity substrate Rogers RO3006 (ϵ_r= 6.15, thickness h=0.128cm) and
- a low permittivity foam layer (ϵ_r=1, h=0.5cm)

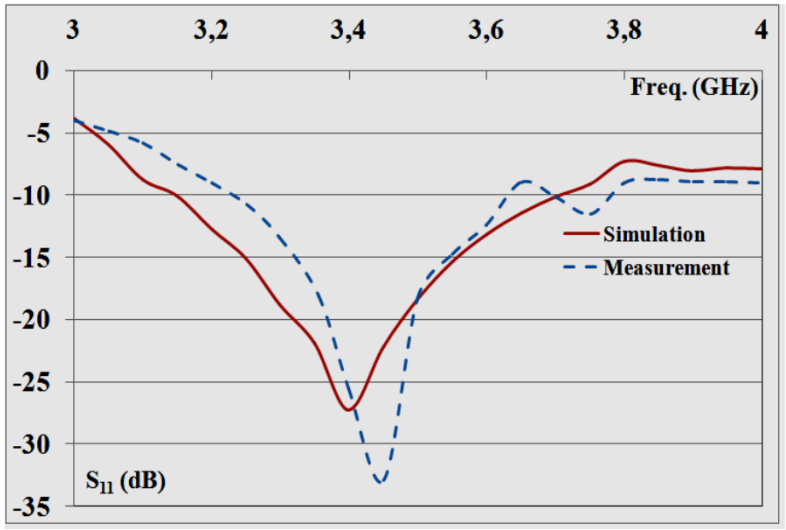


- Planar 4×4 modified E-shaped patch array



- Cross section of the planar 4×4 modified E-shaped patch array

Phased array design and evaluation (cond't)



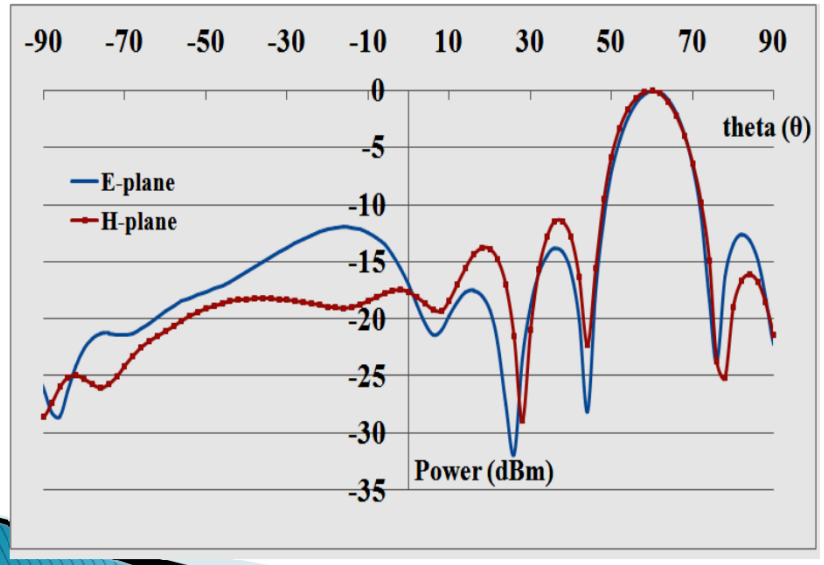
- S_{11} of the modified E-shape radiation element providing:
- Resonance at 3.42GHz
- Bandwidth 12.4%

	Size (cm)	Gain (dB) for 3.4GHz	HPBW xz plane (deg)	HPBW yz plane (deg)
Backhaul antenna (experiment)	32.6×30	21.2	14.4	14.3
Specifications of IEEE802.16j		18	15	15

- Specification comparison between the planar 4×4 modified E-shaped antenna array and the air-interface of the IEEE802.16j standard

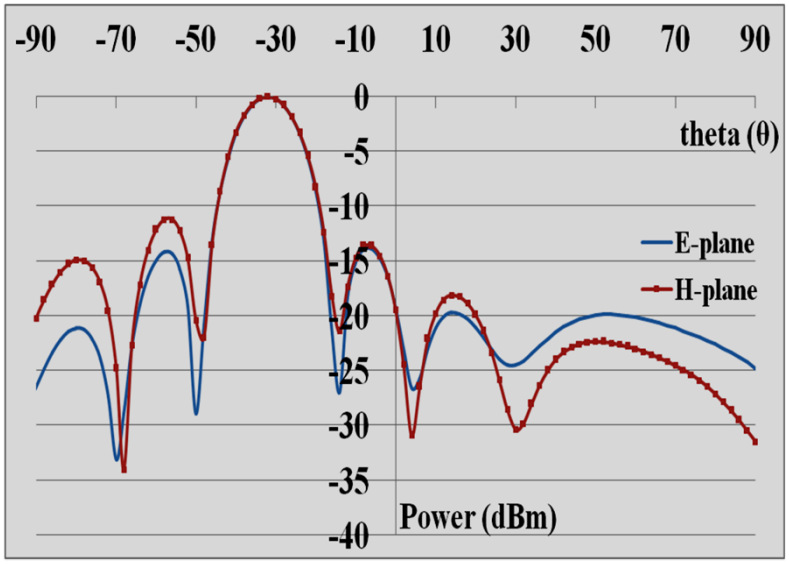
Beam-forming scenario simulations

- Moreover the radiation pattern of the proposed array can be shaped, according to specific requirements.
- Beam-forming can be realized by adjusting the amplitude and phase of the excitation currents that will feed the array.
- Two degrees of freedom (amplitude and phase) provide wide variety of beam-forming scenarios.



• 2-D radiation pattern of the 4×4 modified E-shaped patch array providing maximum at $\theta=60^0$ and Side Lobe Level (SLL)<-10dB

Beam-forming scenario simulations (cond't)

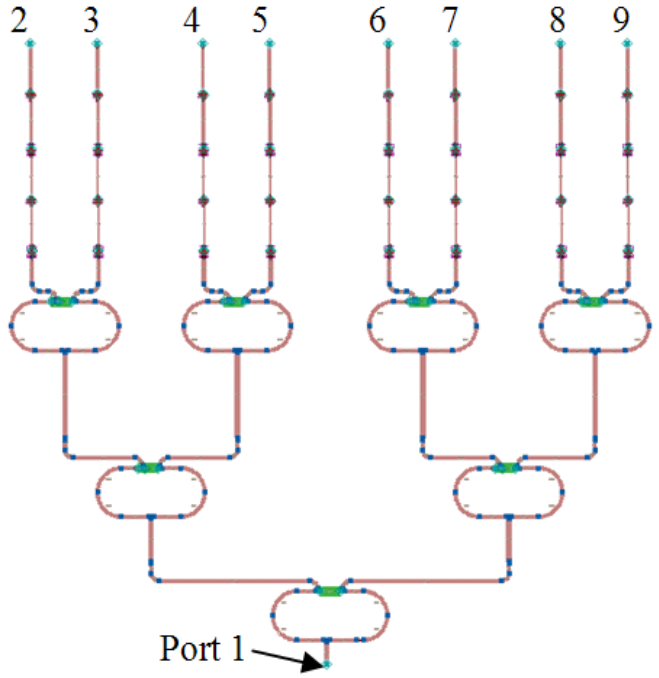


- 2-D radiation pattern of the 4×4 modified E-shaped patch array providing maximum at $\theta=-30^0$ and Side Lobe Level (SLL)<-10dB

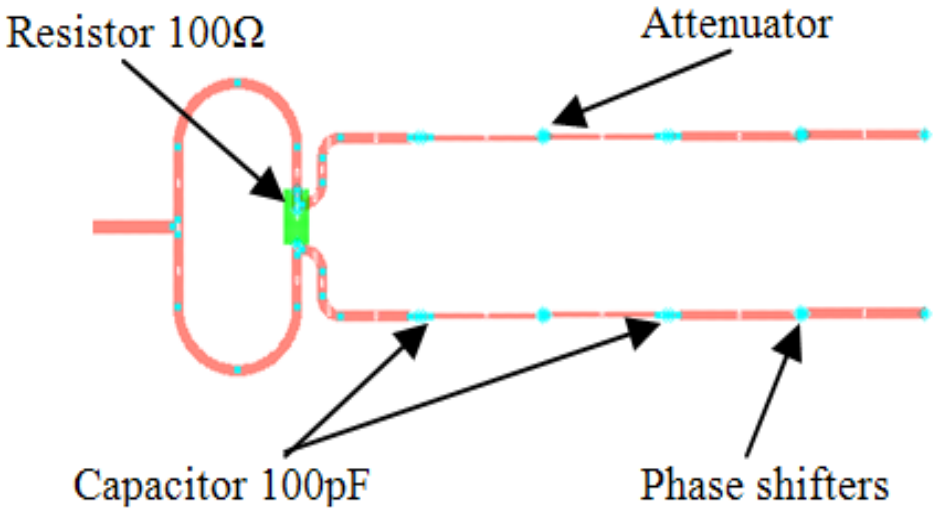
Beam-forming module design

- Beam-forming module is a 1:8 Wilkinson power divider which also adjusts current amplitude and phase values for the excitation of the antenna array.
- It utilizes microstrip technology based on Rogers RO4003 substrate (ϵ_r=3.55, thickness h=0.508mm) on the top of which the microstrip line circuit is designed and on the bottom a ground plane is mounted.
- Two such circuits are used for the excitation of the planar 4×4 modified E-shaped antenna array.
- SMT attenuators and phase shifters have been adjusted in the circuit for beam-forming purposes.

Beam-forming module design (cond't)



- Top view of 1:8 Wilkinson power divider



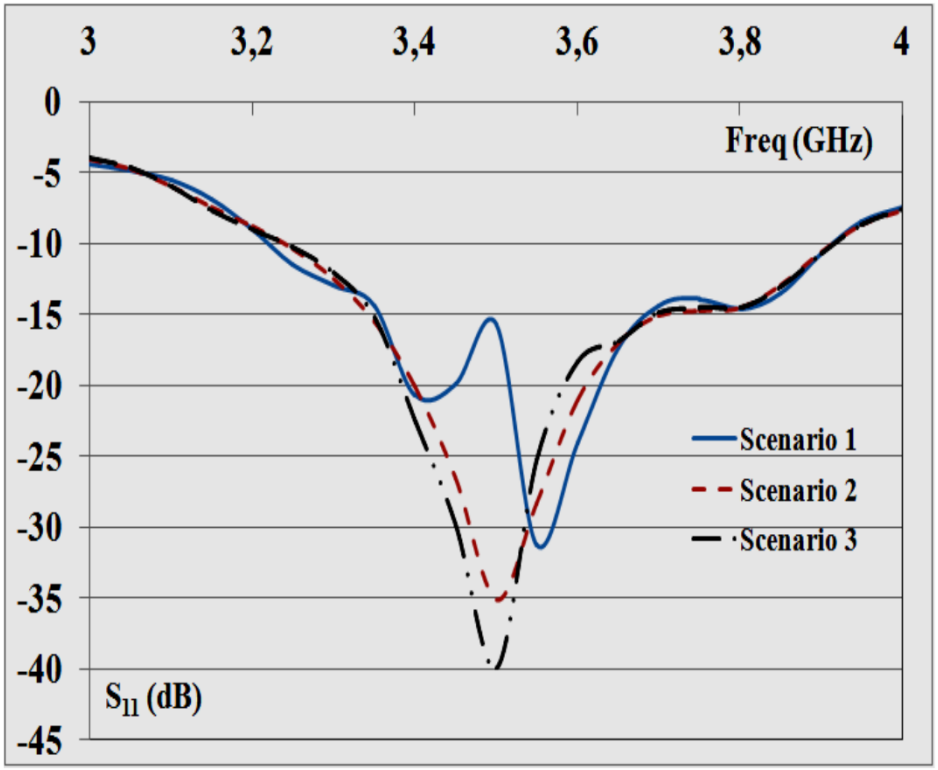
- Wilkinson power divider with component description

Beam-forming module evaluation (cond't)

- Three combinations of attenuation/phase are considered and relevant diagrams of S parameters are obtained.

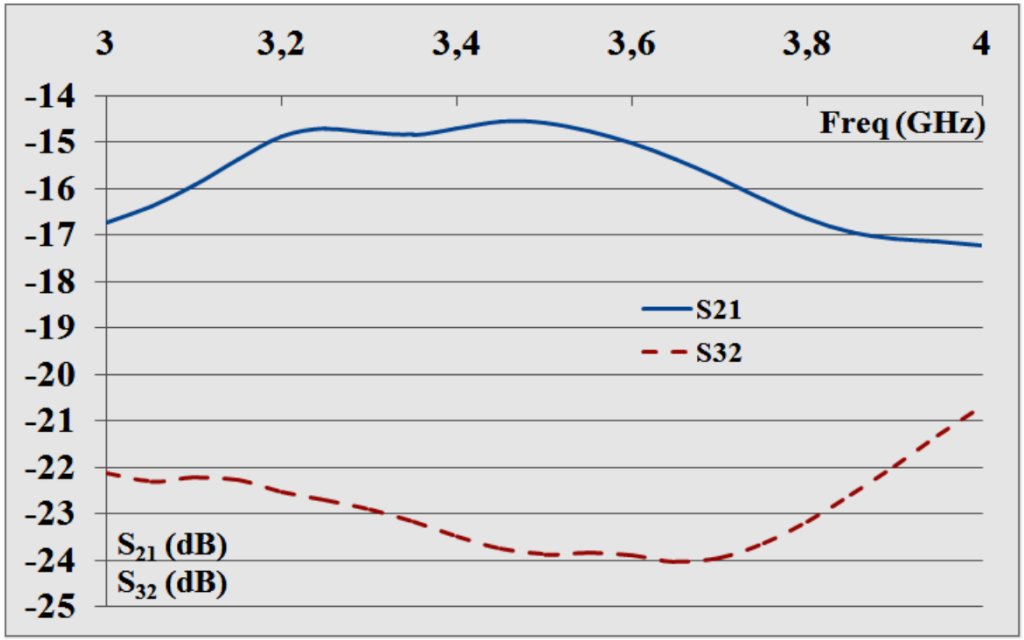
Port	2	3	4	5	6	7	8	9
Scenario 1								
Att. (dB)	0	0	0	0	0	0	0	0
Phase (deg)	0	0	0	0	0	0	0	0
Scenario 2								
Att. (dB)	0	3	6	9	12	15	18	21
Phase (deg)	0	5.6	11.2	16.8	22.5	28.1	33.7	39.3
Scenario 3								
Att. (dB)	0	6	12	18	24	30	36	42
Phase (deg)	0	16.8	33.7	50.6	67.5	84.3	101.2	118.1

- Attenuation/phase scenarios



- S_{11} parameter for the three scenarios providing 650MHz bandwidth (S_{11}<-10dB) in the 3.5GHz frequency band

Beam-forming module evaluation (cond't)



- Insertion loss (S_{21}) and Isolation (S_{32}) for scenario 1 are depicted.
- Insertion loss (S_{21}) varies from -17.5dB to -14.2dB
- Isolation is maintained below -20dB for all frequency range

Conclusions

- In this paper a phased antenna array was presented in order to be incorporated in a Relay Station to establish communication with the super-ordinate Base Station.

- The proposed system includes a 4×4 modified E-shaped patch array suitable for beam-forming applications, based on a planar stacked geometry, providing experimental gain of 21.2dB and 12.4% bandwidth at 3.5GHz frequency band.

- Two beam-forming scenarios were considered and relevant radiation patterns were extracted proving the validity and efficiency of the proposed array.

- The presented array is compliant with the air-interface specifications of the IEEE802.16j standard for backhaul links realization.

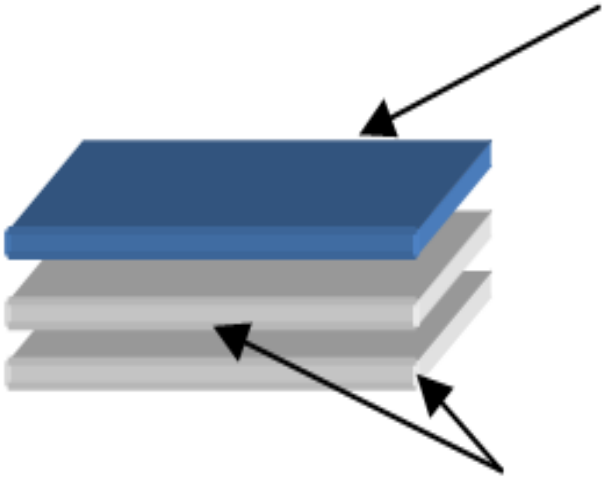
- A beam-forming module has been designed and simulated for power division and attenuation/phase adjustment of the excitation currents to be connected to the presented array.

- Beam-forming module is based on Wilkinson power division technology and has been studied in terms of S_{11}, S_{21} and S_{32} presenting 650MHz bandwidth around 3.5GHz frequency band for several combinations of attenuation/phase of excitation currents.

Conclusions (cond't)

- Two 1:8 Wilkinson power dividers are incorporated in cascaded structure for the excitation of the array, providing an antenna system of low profile and easy to mount for a Relay based WiMAX network.

4×4 modified E-shaped array



1:8 Wilkinson power divider

- Planar phased array configuration
- The presented array is compliant with the air-interface specifications of the IEEE802.16j standard for backhaul links realization
- Beam-forming module is proved to operate efficiently at the 3.5GHz frequency range

ACKNOWLEDGMENT

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